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Artigo Original

Metabolic syndrome components relationship with lipid indices and anthropometric parameters in rural workers: exploratory factor analysis

Relação dos componentes da síndrome metabólica com índices lipídicos e parâmetros antropométricos em trabalhadores rurais: análise fatorial exploratória

Relación de los componentes del síndrome metabólico con índices lipídicos y parámetros antropométricos en trabajadores rurales: análisis factorial exploratório

Analie Nunes Couto[1] ORCID 0000-0003-4819-5516

Carla Helena Augustin Schwanke[1] ORCID 0000-0002-0397-771X

Hildegard Hedwig Pohl[2] ORCID 0000-0002-7545-4862

[1] Escola de Medicina, Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, RS – Brazil.

[2] Universidade de Santa Cruz do Sul, Santa Cruz do Sul, RS - Brazil.

E-mail: analiecouto@hotmail.com

Address: Av. Ipiranga, 6681 – Prédio 12A – 2º andar – sala 201 - Partenon, Porto Alegre – RS

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ABSTRACT

Background and Objectives: The search for simple and rapid screening indicators for metabolic syndrome (MS) is important due to its high frequency in the adult population. And this aspect is little explored in the rural Brazilian population. The objective of this study was to verify the relationship of MS components with lipid indices and anthropometric parameters in rural workers. **Methods**: Cross-sectional study with rural workers aged 18 years or older. The MS was determined through harmonized criteria. The fasting glucose (GLI), systolic (SBP) and diastolic (DBP) blood pressure, HDL-c and waist circumference (WC); anthropometric parameters: body mass index (BMI), waist/height ratio (WHtR) and body fat percentage (%F); and lipid indices: glycemic triglyceride index (TyG), lipid accumulation product (LAP) and visceral adiposity index

(VAI). Exploratory factor analysis was performed that included, in model I, the anthropometric parameters and, in model II, the lipid indices. **Results**: out of the 167 workers, 21.0% were older adults (≥60 years), 39.5% were male and 61.1% had MS, with a higher prevalence in females. Model II responded to the highest explained variance (78.43%) including metabolic (VAI, LAP, TyG and TG and -HDL-c), cardiometabolic (SBP, DBP and CC) and glycemic factors. Model I explained 70.4% of the variance, which included excess weight, blood pressure and lipid/glycemic factors. **Conclusion**: the model that included the lipid indices explained the greatest variance observed and the VAI presented the most significant load of this factor.
Keywords: *Metabolic Syndrome. Anthropometry. Index. Health of the Rural Population. Rural Workers.*

RESUMO

Justificativa e Objetivos: A busca por indicadores simples e rápidos de rastreio de síndrome metabólica (SM) é importante, devido a sua alta frequência na população adulta. Contudo, este aspecto é pouco explorado na população rural brasileira. O objetivo deste estudo foi verificar a relação dos componentes da SM com índices lipídicos e parâmetros antropométricos em trabalhadores rurais. **Métodos:** Estudo transversal com trabalhadores rurais com 18 anos ou mais. A SM foi determinada pelo critério harmonizado. Foram investigados os seguintes componentes da SM: triglicerídeos (TG), glicose em jejum (GLI), pressão arterial sistólica (PAS) e diastólica (PAD), HDL-c e circunferência da cintura (CC); os parâmetros antropométricos: índice de massa corporal (IMC), relação cintura/estatura (RCE) e percentual de gordura corporal (%G); e os índices lipídicos: índice triglicerídeos glicemia (TyG), produto de acumulação de lipídios (LAP) e índice de adiposidade visceral (VAI). Foi realizada análise fatorial exploratória que incluiu, no modelo I, os parâmetros antropométricos e, no modelo II, os índices lipídicos. **Resultados:** Dos 167 indivíduos investigados, 21,0% eram idosos (≥60 anos), 39,5% do sexo masculino e 61,1% apresentaram SM, com maior frequência no sexo feminino. O modelo II respondeu a maior variância explicada (78,43%) incluindo os fatores metabólico (VAI, LAP, TyG, TG e o -HDL-c), cardiometabólico (PAS, PAD e CC) e glicêmico. O modelo I explicou 70,4% da variância, que incluiu os fatores excesso de peso, pressão arterial e lipídico/glicêmico. **Conclusão:** o modelo que incluiu os índices lipídicos explicou a maior variância observada e o VAI apresentou a carga mais significativa desse fator.
Descritores: *Síndrome Metabólica. Antropometria. Índice. Saúde da População Rural. Trabalhadores Rurais.*

RESUMEN

Antecedentes y objetivos: La búsqueda de indicadores de detección simples y rápidos para el síndrome metabólico (SM) es importante debido a su alta frecuencia en la población adulta. Y este aspecto es poco explorado en la población rural brasileña. El objetivo de este estudio fue verificar la relación de los componentes del SM com índices lipídicos e parámetros antropométricos en trabajadores rurales. **Métodos**: estudio transversal con trabajadores rurales de 18 años o más. El SM fue determinado por criterio armonizado. Se investigaron los seguientes componentes de la SM: triglicéridos (TG), glucosa en ayunas (GLI), presión arterial sistólica (PAS) y diastólica (PAD), HDL-c y circunferencia de cintura (CC); parámetros antropométricos: índice de masa corporal (IMC), relación cintura /talla (WHtR) y porcentaje de grasa corporal (% F); y

índices de lípidos: índice glucémico de triglicéridos (TyG), el producto de acumulación de lípidos (LAP) y el índice de adiposidad visceral (VAI). Se realizo um análisis factorial exploratorio que incluyó, em modelo I, los parâmetros antropométricos y, en el modelo II, los índices lipídicos. **Resultados**: De los 167 trabajadores, 21,0% eran ancianos (≥60 años), 39,5% hombres y 61,1% tenían SM, con mayor frecuencia en mujeres. El modelo II respondió a la mayor varianza explicada (78,43%) incluyendo factores metabólico (VAI, LAP, TyG y TG y -HDL-c), cardiometabólico (SBP, DBP y CC) y glucémico. El modelo I explicó el 70,4% de la varianza, que incluía exceso de peso, presión arterial y factores lipídicos / glucémicos. **Conclusión**: el modelo que incluyó los índices lipídicos explicó la mayor varianza observada y el VAI presentó la carga más significativa de este factor.
Palabras clave: *Síndrome Metabólico. Antropometría. Índice; Salud de la Población Rural. Trabajadores Rurales.*

INTRODUCTION

Metabolic Syndrome (MS) has been widely studied in the world due to its negative repercussions on the health of individuals. This syndrome is a major public health problem because of its strong association with cardiovascular diseases and diabetes type 2. It is characterized by a set of metabolic changes and grouped risk factors, including central obesity, high levels of triglycerides (TG), high arterial pressure, low levels of cholesterol of lipoprotein of high density (HDL-c), and hyperglycemia[1].

The higher rates of mortality and morbidity in Brazil are a consequence of cardiometabolic diseases and diabetes [2]. The prevalence of MS in the Brazilian adult population, encountered through the National Health Research (NHR) of 2013, is 38.4%, being higher among women, related to low educational level and with advanced age [3]. In a study with a rural population carried out from 2004 to 2005, 14.9% of the patients were diagnosed [4].

The conventional anthropometric measures such as the body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR) fat percentage (%F) can predict multiple metabolic risk factors [5]. However, some of the conventional parameters have been less precise to predict the MS because they provide limited information about corporal fat distribution [6].

The setting of substitute markers to easily and effectively diagnose is essential to the MS screening. Recently, new predictors were also validated in different populations, such as the visceral adiposity index (VAI), calculated based on the body mass index (BMI), waist circumference (WC), and lipid characteristics (TG and HDL-c), the lipid

accumulation product (LAP) based on the combination of serum triglycerides (TG) and WC levels, and the product of plasmatic glucose levels and TG (index TyG) [7, 8, 9].

Nevertheless, the relationship between components of the metabolic syndrome, anthropometric measures, and lipid indices, to the best of our knowledge, still was not evaluated in rural workers. Hence, the objective of this study was to verify the relation of MS components with lipidic indices and anthropometric parameters in rural workers.

METHODS

Study design

Transversal study.

Study population

We used the data of 167 rural workers selected in a sample by convenience from the Project "*Triagem de fatores de risco relacionados ao excesso de peso em trabalhadores da agroindústria usando novas tecnologias analíticas e de informação em saúde*" collected from 2013 to 2016. We included rural workers from Vale do Rio Pardo/RS, over the age of 18 years old, who had held all the variables for the lipid index calculation. We excluded pregnant women, individuals with neurological or motor impairments that could hamper the evaluation, and those who used insulin.

Procedures and data collection

We obtained the data in a single day through undergraduate and graduate students and trained professionals registered in a data bank and collected according to the description. We collected the demographic data (age and gender) through a standardized questionnaire of the project.

The biochemical parameters concerned fasting serum dosage glucose (GLI), TG, and HDL-c. We carried out the blood collection, through venipuncture technique, during the morning after twelve hours of night fasting. We carried out the biochemical analysis in serum and plasma samples (EDTA/Fluoride) in the Miura 200 (I.S.E., Rome, Italy) automatized equipment, utilizing commercial kits from Kovalent (Kovalent from Brazil). We carried out the collection and the biochemical analysis in the Exercise Biochemistry Laboratory from UNISC.

The anthropometrics parameters investigated were BMI, WC, WHR, and F%. We assessed the weight, height, WC, and skinfolds in the Physical Activity Laboratory of UNISC. We calculated the body mass index (BMI) with weight/height. We assessed the weight and the height utilizing the anthropometric scale platform type (Welmy SA, Santa Bárbara do Oeste, Brazil), capacity 150kg with the division of 100g and stadiometer coupled with a 1mm precision. We used the non-extendable measuring tape at the midpoint between the lower and upper coastal border of the iliac crest to measure the WC in a perpendicular plane. We determined the WHR through the relationship between the WC (cm) and the height (cm). We estimated the %F obtaining the corporal density calculated by the sum of seven skinfolds (chest, triceps, subscapular, suprailiac, abdominal, thigh, and midaxillary, with three repetitions) and later calculated the Siri's equation 10 %F = [(4,95/DENS) – 4,50] x 100. We utilized the compass Lange model to measure the skinfolds.

We measured the systolic blood pressure (SBP), and the diastolic (DBP) with the individual rested in 5 minutes in a calm environment, with an empty bladder, sitting, with feet supported on the ground, two times with a mercury sphygmomanometer, according to the 7th Brazilian Guideline for Arterial Hypertension [11].

For the MS identification, we utilized the clinical criteria defined according to the harmonized criteria of the American Heart Association/National Heart, Lung, and Blood Institute (AHA/NHLBI) and the International Diabetes Federation (IDF)[1]. The presence of any 3 or 5 risk factors constitutes a diagnosis of MS: WC ≥ 90 cm for men and ≥ 80cm for women (the cutoff for the South-American population), TG ≥ 150mg/dL or drug treatment, fasting blood glucose ≥ 100mg/dL or drug treatment, arterial pressure ≥ 130/85mmHg or drug treatment.

Regarding the lipid index:

- We calculated the VAI through the equations: Men= [WC/39,68 + (1,88 x BMI)] × [TG (mmol/L)/1,03] × [1,31/HDL-c (mmol/L)]; Women= [WC/36,58 + (1,89 × BMI)] × [TG (mmol/L)/0,81] × [1,52/HDL-c (mmol/L)] [7].
- We calculated the LAP through the equations: Men= [WC (cm) - 65] × [TG (mmol/l)]; Women= [WC (cm) - 58] × [TG (mmol/l)] [8].
- We calculated TyG as: Nl [fasting triglycerides (mg/dl) x fasting glucose (mg/dl) / 2], where Nl (natural logarithm) [9].

Ethical aspects

The Research Ethics Committee of the *Universidade de Santa Cruz do Sul* (CEP-UNISC) approved the project CAAE: 43252721.1.0000.5343. All the participants signed the Consent Form accordingly to Resolution 466/2012 of The National Health Council - Health Ministry.

Statistical analysis

We carried out the analysis in the SPSS (Statistical Package for the Social Sciences) software for Windows 23.0 version (IBM, Armonk, NY, USA). We presented the descriptive characteristics of the participants as frequency (relative frequency) and the continuous variables expressed as average ± standard deviation and/or median (interquartile range 25-75). We tested the normality using the Kolmogorov-Smirnov test. We utilized the t-Student test to compare the averages between genders, and we calculated the medians using the U test of Mann-Whitney. We utilized Spearman's and Pearson's correlation tests to calculate the correlation coefficients between continuous variables. The level of significance adopted was 5% ($p<0.05$).

We carried out the exploratory factorial analysis in two models: I- to investigate the relation between the components of MS (WC, PA, GLI, TG, and HDL-c) the anthropometric parameters (BMI, WHR, and %F); II- to investigate the relation between the components of MS and the lipidic indices (TyG, VAI e LAP).

We utilized the method of main components analysis aiming to reduce the number of original variables in less latent factors. The factorial analysis consists of three steps: factorial extraction, which produces the minimum number of factors that retain the maximum possible total variance of the original data; varimax rotation, to make the factors more easily interpretable; and interpretation-based on rotated factor loadings. Higher factor loadings represent a higher correlation between the variable and the latent factor.

The Kaiser-Mayer-Olkin (KMO) method was estimated in >0.6, and Bartlett's test of sphericity was significant ($p <0.001$) as an indicator of the adequacy of the sample in the analysis. We extracted the number of factors based on identified factors with eigenvalues >1. We interpreted the factors based on loads that relate the variables to the factor because higher factor loadings represent more correlation between the variable and the latent factor. We considered the factor loadings > 0.4 significant to identify the variables that compose a factor, according to Tsai et al.[12].

RESULTS

Out of the 167 rural workers who took part in this study, 79.0% (N= 132) were adults and 21.0% (N= 35) were older adults (over the age 60 years), and 60.5% (N= 101) were female and 39.5% were male. The average age was 50.49 ± 10.76 years (men = 50.62±10.82 years; women = 50.41±10.78 years), varying between 18 and 73 years.

The frequency of the metabolic syndrome was 61.1% (N= 102) in the final sample, 67.6% were female and 32.4% (N= 33) were male. We presented the anthropometric and metabolic characteristics of the final sample and by gender in Table 1. The female gender reported average/median significantly superior in comparison to males for BMI, WHR, %F, VAI, LAP. Males, on the other hand, presented a significantly superior average for WC.

Table 1. Metabolic, anthropometric, and lipid indices characteristics in the total samples according to gender

		Gender		
Variables	**Total sample (N= 167)**	**Male (N= 66)**	**Female (N= 101)**	***P***
CC (cm)	90.99±9.68	93.00±9.46	89.68±9.64	**0.030***
TG (mg/dL)	108.31 (80-158)	98.46 (76,3-152.7)	111 (84.1-162.5)	0.263
SBP (mmHg)	130 (120-142)	126.50 (120-140)	130 (118-143)	0.449
DBP (mmHg)	80 (76-89)	80.00 (71.5-90)	80.00 (76-88)	0.894
GLI (mg/dL)	100.4 (92-112)	100.20 (95-116.5)	100.66 (90.40-109)	0.184
HDL-c (mg/dL)	51.23 ± 10.99	49.68 ± 10.26	52.24 ± 11.38	0.141*
BMI (kg/m²)	28.47 (25.91-3.68)	27.07 (25.5-29.28)	29.94 (26.75-33.72)	**0.001**
WHR	0.55 ± 0.06	0.54 ± 0.05	0.56 ± 0.06	**0.026***
%F	28.31 (22.10-32.04)	21.62 (18.53-24.38)	31.22 (29.21-34.17)	**0.001**
VAI	1.47 (0.96-2.40)	1.09 (0.83-2.01)	1.75 (1.18-2.7)	**0.001**
LAP	36.09 (21.80-36.09)	30.27 (18.8-54.43)	39.20 (24.92-61.4)	**0.050**
TyG	8.66 ± 0.51	8.64 ± 0.55	8.67 ± 0.48	0.730*

WC (waist circumference); TG (triglycerides); SBP (systolic blood pressure); SBP (Diastolic blood pressure); GLI (fasting blood glucose); HDL-c (high density lipoprotein); BMI (Body mass index); WHR (waist-height ratio); %F (Fat body percentage); VAI (Visceral Adiposity Index); LAP (Lipid Accumulation Product); TyG (triglyceride/glucose index); *t-Student test for independent samples, average results (± standard deviation); Mann-Whitney's test, median results (interquartile range 25-75). Considering p <0.05 (5%) significant.

We presented the correlation between the 12 analyzed variables that configure MS components, anthropometric measures, and TyG, LAP, and VAI indices in Table 2. In the correlation test among the anthropometric parameters and the components of MS, we found a significant correlation, positive and strong of BMI with WC (r=0.776) and weak of SBP, DBP, and TG. The WHR correlated positively, strongly, and significantly with WC (r=0.884), and with SBP, DBP, GLI, and TG. On the other hand, the %F obtained a weak correlation, positive and significant with WC, SBP, and TG. By correlating the lipid indices and the components of the metabolic syndrome, we determined a significant, strong, and positive correlation for TyG, LAP, and VAI with TG (r= 0.951, r= 0.864, r= 0.914, respectively). The VAI presented moderate and an inverse correlation with HDL-c (r= -0.607) and weak and significant correlation with WC (r= 0.295). The TyG and LAP indices presented an inverse proportional correlation with HDL-c (r= -0.380; r= -0.348) and positive with the other MS variables.

Table 2. Correlation among the Metabolic Syndrome components, anthropometric measures, and lipid indices.

Variables	WC*	SBP	DBP	Glucose	HDL-c*	TG	BMI	RCE*	%F	TyG*	LAP	VAI
WC*	1	0.265**	0.333**	0.196*	-0.153* ŧ	0.331**	**0.776****	**0.884**** ŧ	0.276**	0.336** ŧ	0.681**	0.295**
SBP	--	1	0.682**	0.264**	0.197*	0.177*	0.255**	0.322**	0.157*	0.239**	0.262**	0.089
DBP	--	--	1	0.213**	0.034	0.187*	0.293**	0.326**	0.148	0.231**	0.290**	0.143
GLI	--	--	--	1	0.126	0.158*	0.144	0.231**	-0.061	0.419**	0.184*	0.137
HDL-c*	--	--	--	--	1	-0.392**	-0.081	-0.067 ŧ	0.012	-0.380** ŧ	-0.348**	-0.607**
TG	--	--	--	--	--	1	0.287**	0.371**	0.213**	**0.951****	**0.864****	**0.914****
BMI	--	--	--	--	--	--	1	**0.876****	0.667**	0.290**	0.639**	0.338**
RCE*	--	--	--	--	--	--	--	1	0.521**	0.351** ŧ	0.717**	0.384**
%F	--	--	--	--	--	--	--	--	1	0.400**	0.427**	0.372**
TyG*	--	--	--	--	--	--	--	--	--	1	**0.844****	**0.870****
LAP	--	--	--	--	--	--	--	--	--	--	1	**0.837****
VAI	--	--	--	--	--	--	--	--	--	--	--	1

WC (waist circumference); SBP (systolic blood pressure); SBP (Diastolic blood pressure); GLI (fasting blood glucose); HDL-c (high density lipoprotein); TG (triglycerides); BMI (Body mass index); WHR (waist-height ratio); %F (Fat body percentage); TyG (triglyceride/glucose (TyG) index); LAP (Lipid Accumulation Product); VAI (Visceral Adiposity Index); ŧ: Pearson's correlation test (parametric variables), Spearman's correlation test; ŧ Pearson's correlation test; Significance of *: $p<0.05$; **: $p<0.001$.

The factorial analysis of the metabolic syndrome components with anthropometric and lipid indices (VAI, LAP, TyG) identified three dominant factors with eigenvalue > 1 in both analyses. The analysis that included the lipid indices responded to the highest total variation of the data (78.4%) if compared with the analysis that included the anthropometric parameters (70.4%). We show the loading patterns of the factorial analysis, after the varimax rotation, in Table 3.

Table 3. Factor loadings of the Metabolic syndrome components with anthropometric parameters and lipid indices in the exploratory factorial analysis **(N= 167).**

Model I MS components + Anthropometric parameters				**Model II MS components + VAI, LAP e TyG**			
Variables	**Factor 1**	**Factor 2**	**Factor 3**	**Variables**	**Factor 1**	**Factor 2**	**Factor 3**
WC	**0.774**	0.269	0.294	**WC**	0.383	**0.563**	0.024
TG	0.248	0.079	**0.696**	**TG**	**0.924**	0.161	0.047
SBP	0.183	**0.887**	-0.060	**SBP**	-0.049	**0.873**	0.141
DBP	0.202	**0.831**	0.040	**DBP**	0.041	**0.860**	0.004
GLI	-0.100	0.368	**0.499**	**GLI**	0.108	0.087	**0.981**
HDL-c	-0.030	0.254	**-0.795**	**HDL-c**	**-0.634**	0.267	-0.045
BMI	**0.943**	0.143	0.066	**VAI**	**0.955**	0.023	0.016
RCE	**0.897**	0.256	0.187	**LAP**	**0.868**	0.395	0.004
%F	**0.763**	-0.036	-0.121	**TyG**	**0.841**	0.218	0.389
Explained variation %	**40.02**	**16.50**	**14.38**	**Explained variation %**	**46.62**	**20.59**	**11.22**
Accumulated variation %	**40.02**	**56.52**	**70.90**	**Accumulated variation %**	**46.62**	**67.21**	**78.43**

BMI (Body mass index) described in kg/m2; WHR (waist-height ratio); %F (Fat body percentage); WC (waist circumference); TG (triglycerides); SBP (systolic blood pressure); SBP (Diastolic blood pressure); GLI (fasting blood glucose); TyG (triglyceride/glucose (TyG) index); VAI (Visceral Adiposity Index); LAP (Lipid Accumulation Product); We selected factors with eigenvalue ≥1 for the analysis. We calculated the factor loadings after the Varimax rotation with Kaiser's normalization of the variables in each extracted factor. All p values are <0,001. Numbers in bold represent variables with factor loadings >0.4.

In the analysis that included the anthropometric parameters (model I), the BMI, WHtR, WC, and %F positively contributed to factor 1. The BMI presented a higher factorial load of this factor. This factor explained 40.02% of the total variance. Factor 3 explained 14.38% of the variation, and the variables TG and glucose presented a

positive contribution, and the HDL-c negatively contributed to this factor. We interpreted factor 1 as a factor of weight excess/obesity. We interpreted factor 2 as the factor of blood pressure. We interpreted factor 3 as the factor of lipid/glycemic.

In the analysis that included the lipid indices (model II), factor 1 was responsible for the higher proportion of the total variance (46.62%) and was positively composed by VAI, LAP, TyG, and TG, while the HDL-c negatively contributed to this factor. VAI presented the most significant load of this factor. SBP, DBP, and WC positively contributed to factor 2, which explained 20.59% of the total variance. The glucose (GLI) positively contributed to factor 3, which explained 11.22% of the total variance. Thus, we interpreted factor 1 as a metabolic factor, factor 2 as cardiometabolic, and factor 3 as a glycemic factor.

DISCUSSION

In this study, we utilized the factorial analysis to reduce interrelated variables that are key components to the metabolic syndrome and/or predictors to three factors not correlated in a sample with rural workers. As far as we know, no previous study has investigated the grouping of components of MS in two distinct models, model I (anthropometric parameters) and model II (lipid indices).

Model II responded with the highest explained variation (78.43%). Included the metabolic factors (VAI, LAP, TyG, TG, and HDL-c), cardiometabolic (SBP, DBP, and WC), and glycemic. The model I explained 73.4% of the variation and included factors of weight excess, blood pressure, and lipid/glycemic. Our results suggest that the indices were better related to the components of the metabolic syndrome.

Similar to our findings, Shin and Kim [8], in their study, identified that LAP, VAI, TyG, and WHtR were positively correlated with WC, SBP, DBP, TG, and fasting glucose level, and negatively correlated with HDL-c. We found these findings in the total sample of men and women.

In a study carried out with individuals in the rural area of India also utilizing cardiometabolic variables in the factorial analysis, three factors were extracted and responded to 71% of the variation. Factor 1 was positively loaded by WC, TG, and very-low-density lipoprotein (VLDL) and negatively loaded by HDL-c. Factor 2 was positively loaded by total cholesterol low-density lipoprotein (LDL-c). Factor 3 was positively loaded by SBP and DBP [13].

Similar to the findings in our study in model I, a study carried out with rural and industry Brazilian workers identified that factor 1 also was strongly loaded with related variables to overweight, obesity, and visceral fat (BMI, visceral fat area, WC, %F). The second factor was loaded by TG, VAI, TyG, and LAP. Factor 3 included L-8, IL-6, IL-1β and GLI [14].

As we observed, similarly to our findings in model II, Shin and Kim[8] and Deshmukh et al.[13] also found positive relation in TG and negative relation with HDL-c in factor 1. Our findings in the model I are similar to the results found in our previous research [14] in factor 1, composed of variables related to the excess of weight/obesity.

The MS is a group of metabolic abnormalities that includes central obesity, insulin resistance, atherogenic dyslipidemia, and hypertension. The prevalence of MS corresponds, generally, to the prevalence of obesity [15], and parameters of general obesity, such as BMI, WC, and WHtR were associated with that syndrome. Among the mechanisms involved in obesity is the resistance to insulin in the adipose tissue, which damages the inhibition of lipolysis mediated through insulin, and there is an increase of circulating free fatty acids that inhibit the antilipolytic effect of insulin. However, the deposits of visceral fat contribute more to the resistance to insulin than the subcutaneous fat being the central obesity the most proposed because it is the main trigger for most of the endocrine and immune pathways of adipocytes involved in MS [15, 16].. There still is not a full comprehension of MS, but insulin resistance is the most accepted hypothesis for the underlying pathophysiology due to the excess of fatty acids because of inadequate lipolysis [17].

In the last decades, the TyG, VAI, and LAP indices were associated with strong predictive capability for the resistance against insulin [9, 18, 19]. These same indices are now usually tested to predict the MS [20, 21, 22]. In an evaluation of the predictive capacity and cut value of 11 parameters related to obesity (BMI, WC, WHR, WHtR, conicity index, VAI, TyG index, among others) in the identification of the MS in adults, we observed that the index TyG and VAI had the highest predictive output in different group ages (30-50 years old and 51-70 years old) in both genders [23].

In our study, we applied factorial analysis in the general population, aiming to explore the higher variation between both models. The factorial analysis considers the underlying correlational structure between the individual markers, minimizes various test problems, and does not require biological suppositions, offering advantages regarding other approaches to create summary variables [24]. However, it is necessary

larger explorations regarding the associations between the conventional anthropometric variables with the lipid indices in the prediction of the metabolic syndrome in the studied population, besides the transverse nature of this analysis and the sample size, not allowing us to extract the sample by gender, which constitutes a fragility in our study. In addition, and for future studies, we may test the results of the exploratory factorial analysis study using a set of independent data but including the same variables.

In conclusion, our study limited itself to exploring the grouping of factors in two independent models and demonstrated that model II, which included the lipid indices VAI, LAP, and TyG, explained the higher variation observed. Hence, the lipid indices investigated presented better relation to the MS components in rural workers, especially the lipid index VAI. However, we suggest that other studies must be carried out aiming to explore the relationship of the lipid indices with other variables such as age (adults and elderly people).

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Authors' contributions:

Analie Nunes Couto contributed to the study design, data analysis and article writing.

Carla Helena Augustin Schwanke contributed to the design, review and final approval of the article.

Hildegard Hedwig Pohl contributed to the planning, conception and design of the project, as well as the present article, review and final approval of the article.

All authors have approved the final version to be published and are responsible for all aspects of the work, including ensuring its accuracy and integrity.